DOCUMENT RESUME

ED 357 326 CS 011 293

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TITLE Deductive Reasoning with Prose Passages: Effects of Prior Knowledge, Inference Form, and Reading Skill.
PUB DATE Mar 93
NOTE 22p.; Paper presented at the Biennial Meeting of the Society for Research in Child Development (New Orleans, LA, March 25-28, 1993).
PUB TYPE Speeches/Conference Papers (150) -- Reports - Research/Technical (143)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS College Freshmen; College Sophomores; Comparative Analysis; *Deduction; Grade 7; Higher Education; *Inferences; Junior High Schools; Junior High School Students; *Prior Learning; Reading Achievement; Reading Research; *Reading Skills; Thinking Skills

ABSTRACT

A study examined how students make specific inferences from prose passages. Subjects, 44 first- and second-year college students and 40 seventh-grade students, read 3 prose passages, each containing 6 inferential questions. The premise information for each question was expressed in one of six deductive inference forms: transitive, exclusive disjunction, modus ponens, denied antecedent, affirmed consequent, and modus tollens. Results indicated that: (1) college students performed better than the seventh graders; (2) for the seventh graders, the ability to reason from false premises expressed in narrative form was correlated with reading skill; (3) for college students, reading ability had a general effect on inferential comprehension, but did not interact with either content or difficulty; and (4) there may be some improvement with age in the ability to reason from premises inconsistent with prior knowledge, provided the type of inference required is not too difficult. Findings suggest that a high level of reading ability helps students to reason about what they read, but does not by itself account for all forms of inferential comprehension. (Two tables and four figures of data are included. Contains 27 references.) (RS)

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ED357326

Deductive Reasoning with Prose Passages: Effects of Prior Knowledge, Inference Form, and Reading Skill

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Manuscript under review: please do not quote

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CS011293

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Deductive Reasoning with Prose Passages: Effects of Prior Knowledge, Inference Form, and Reading Skill

Reasoning, one of the many psychological processes involved in reading, appears to affect comprehension in important ways. Overton (1990) defines reasoning as thinking that requires inference. Inference, he notes, is the process whereby one proposition (the conclusion) is arrived at and accepted on the basis of other propositions (the premises) that were originally accepted. This same process is frequently required of readers attempting to comprehend prose. Information explicitly stated in passages (the premises) is accepted and used to draw conclusions about the meaning of the material being read. Since very few prose passages contain no implied relationships, the ability to make inferences is a necessary skill for reading comprehension.

The purpose of the present study was to apply insights from the logical reasoning literature to the study of how students make specific inferences from prose passages. The study focused on deductive inferences for several reasons. First, logically necessary inferences rarely have been distinguished from probable inferences in the reading literature, so little information is available about how people make deductive inferences while reading. Second, logical reasoning studies have indicated that some deductive inference forms are more difficult to process than others, and that there are developmental trends in the ability to understand different inference forms (Braine & Rumain, 1981; Breslow, 1981; O'Brien, 1987; Overton, 1990; Rumain, Connell, & Braine, 1983; Wildman & Fletcher, 1977). Finally, deductive inferences require understanding of the concept of logical necessity, and understanding this concept involves abilities useful in reading comprehension.

Premise information in six different forms was embedded in prose passages, and subjects were asked to make inferences based on these inference forms. The first three forms have been demonstrated to be relatively easy for children even younger than the youngest subjects in this study (Braine & Rumain, 1983; Breslow, 1981; Moshman & Franks, 1986) while the last three types have been shown to be more difficult, even for adults (Braine & Rumain, 1983; Kodroff

& Roberge, 1975; Taplin & Staudenmayer, 1973; Taplin, Staudenmayer, & Taddonio, 1974).

Effects of prior knowledge were explored by expressing the different inference forms in story contexts that were either empirically true, empirically false, or neutral (e.g., blorks are bigger than argbeasts).

In an earlier study of the above factors and how they affect reading comprehension (Franks, 1989) all the subjects had at least average reading ability. Since inference-making in general is considered a reading skill, it seems instructive to consider whether good readers differ from poor readers in their inferential comprehension ability. A number of studies have looked at this variable, though in different ways. With regard to recall, for example, good readers recall more explicit and implicit information than poor readers, respond more effectively to probes of their recall, and generate more causal and conditional connections between propositions (Bridge & Tierney, 1981; Tierney, Bridge, & Cera, 1978-1979).

Questions directly assessing inference-making reveal better performance for good readers than for poor readers, but only for some types of inferential questions (Olson, 1985). While Wilson (1979), found that average readers performed better than below average readers on inferential, but not on factual questions, Hildyard & Olson (1978) found that reading ability affected subjects' skills at recognizing that pragmatic inferences were not necessarily true, but found no ability effects for several other types of inference and memory questions.

It also appears that good readers are better than poor readers at recognizing situations when inferences should not be made. August, Flavell, and Clift (1984) asked skilled and unskilled fifth-grade readers to read stories, some of which had a page missing. Skilled readers correctly reported the missing page significantly more often than unskilled readers, who were more likely to generate inferences to "fix up" the stories with missing information. Using a false recognition task, Waller (1976) found that good readers were less likely than poor readers to think they had read sentences they had not read, even when those sentences were semantically consistent with the ones that had been read. There are times when

making an inference is not the appropriate thing to do; good readers seem to recognize this more readily than poor readers.

Whatever the effect that reading ability has on inferential comprehension, we cannot simply say that good readers are always better at inferential questions or always more likely to make inferences about what they read than are poor readers. It appears to depend on the type of inference required. Moreover, not all studies show positive effects for reading ability. In their study of prerequisite relations among different types of inference questions, Davey and Macready (1985) looked at the effects of those questions on good and poor sixth-grade readers. They found that all their questions appeared to assess the same underlying attribute and require the same skills regardless of the reading ability of the subjects. Malicky and Schienbein (1981) found both average and poor readers able to make inferences when material was presented at their instructional level, rather than at the level of their grade placement.

Since the effects of reading ability on inference-making seem quite variable, exploring these effects on a task requiring deductive inference could provide some insight about the relationship between reading and thinking. While such effects could occur at any age, an earlier experiment (Franks, 1989) suggested the presence of some developmental trends in logical reasoning skill even with younger subjects who had high levels of reading ability. To avoid confounding reading skill with the general level of cognitive development required for optimal performance on the task, the relationship between reading ability and inferential comprehension was explored with seventh-grade and college-aged students.

Method

Subjects. College-aged subjects were 44 first- and second-year students (15 male and 29 female; mean age=20-5) recruited from introductory psychology classes at a Southeastern state university. All students had taken Form E of the Nelson-Denny Reading Battery (Brown, Bennett, & Hanna, 1981) as incoming freshmen. The test contains two sections: a vocabulary subtest with 100 multiple-choice items and a comprehension subtest containing eight reading passages and 36 questions, half literal and half requiring some kind of inference or interpretation.

Subjects' Total Reading raw scores (Vocabulary plus two times

Comprehension) were used in this experiment. The scores for this sample ranged from 54 (8th percentile) to 157 (98th percentile), with a mean Total Reading score of 103.11 (62nd percentile).

There were 40 seventh-grade subjects (28 girls and 12 boys; mean age=13-5). This sample included the seventh-graders from the previous study, with an additional 10 seventh-graders whose reading scores were below the 50th percentile on the California Achievement Test. All the students were recruited from the same junior high school in a Midwestern city. Their Total Reading percentile ranks ranged from the 6th to the 99th percentile. Because only percentile ranks were available for this group, the percentiles were converted to Z-score values for analysis in this experiment.

Materials. Materials consisted of a test booklet with three prose passages, each containing six inferential questions, and a sample passage. All questions were placed within stories, directly following the paragraphs containing the premises from which students were to draw conclusions. In one passage, all of the premise information was empirically true on the basis of subjects' prior knowledge (e.g., adults are older than children; butterflies are bigger than ladybugs); in another, all information was inconsistent with subjects' prior knowledge (e.g., cats are bigger than horses; driving north leads you to the south end of town); and in the third, the content was neutral--that is, subjects drew conclusions based on premises whose empirical truth was unknown on the basis of their prior knowledge (e.g., locations and functions of equipment on an imaginary spaceship).

The premise information for each question was expressed in one of six deductive inference forms: (1) Transitive, (2) Exclusive Disjunction, (3) Modus Ponens, (4) Denied Antecedent, (5) Affirmed Consequent, and (6) Modus Tollens. Instead of being phrased in the standard formal logic style, the premises of each inference form were embedded in the passages, and the questions following the premises required a deductive conclusion. In order to answer the questions correctly, subjects did not simply have to infer something not stated, but were required to make specific types of inferences, based on the form of statements in the passages. For each question, subjects chose between responses of "yes," "no," and "can't tell." The same six inference forms appeared in the same order in all

three passages and alternated between the easier forms and the more difficult ones; what differentiated the three passages was the context in which the inference forms were embedded (true, false, or neutral). The sample passage contained three simple inferential questions for which the correct answers were "yes," "no," and "can't tell," respectively, to ensure that subjects realized that all three of these responses were potentially correct choices.

Procedure. All subjects received the same test booklet, worked through the sample passage with guidance from the examiner, discussed the correct answers for the sample questions, read the same passages, and answered the same questions. The order of presentation of the true, false, and neutral content passages was counterbalanced at each grade level by using each possible order equally often. Subjects were all tested in classroom settings in groups ranging from two to fifteen in size. Subjects were allowed as much time as they needed to complete the task; most took between twenty and thirty minutes.

Results

Using a split-plot analysis of variance, scores were first collapsed over age and analyzed with gender as a factor. No main effect for gender was found, nor did this factor iteract with the other variables. In contrast to a previous experiment (Franks, 1989), overall performance on all three stories differed significantly between the seventh graders (Mean=11.20; Standard Deviation=1.98) and the college students (Mean=12.66; Standard Deviation=1.31) in this experiment ($F(1, 82)=16.16$; $p<.001$). No significant interactions occurred between age of subjects and the Content or Difficulty variables. Because different reading measures were used for the seventh-graders and the college students, separate analyses were performed to explore the effects of Reading Ability, Content, and Difficulty for each group.

Analysis of covariance, with two levels of Difficulty, three levels of Content, and Reading Ability as the covariate, was used to explore the effects of reading skill on the other variables. Repeated measures analysis of variance without the covariate was then used to look at within-subjects effects of the other two variables.

For the seventh-grade sample, a significant interaction between Content and Reading Ability ($F(2, 37)=3.59$; $p<.05$) was observed, indicating different effects of reading ability with the three content types. Separate regression equations (plotted in Fig. 1) show these effects. With true content, students at all levels of reading skill performed approximately equally well; a test of this regression was not significant. With false content, however, performance improves significantly as reading skill improves ($F(1, 38)=10.52$; $p<.05$). Finally, performance with neutral content does not improve significantly as reading skill increases; the test of this regression was not significant.

No interaction was observed between Reading Ability and Difficulty; regardless of their reading skill, seventh-graders performed better with easy inference forms than with hard ones (see Fig. 2).

Repeated measures ANOVA without the covariate revealed significant within-subjects effects for both Content ($F(2, 78)=18.93$; $p<.001$) and Difficulty ($F(1, 39)=132.10$; $p<.001$). Subjects' scores were significantly higher with easy than with difficult inference forms (see Table 1). Pairwise comparisons (with Bonferoni's correction) indicated that performance with true content was significantly better than performance with both false content ($F(1, 39)=16.40$; $p<.001$) and neutral content ($F(1, 39)=40.05$; $p<.001$). Performance with false content was not significantly better than performance with neutral content ($F(1, 39)=4.16$; $p>.01$) (see Table 1). No significant interaction was observed between the content and difficulty variables for this group of seventh graders.

For the college sample, analysis of covariance revealed no significant interactions among any of the factors. Overall performance improved as reading ability increased, but this effect was not significantly different for the two levels of difficulty (see Fig. 3) or with different content types (see Fig. 4).

Repeated measures analysis of variance without the covariate again indicated significant within-subjects effects for Content ($F(2, 86)=34.29$; $p<.001$) and Difficulty ($F(1, 43)=264.20$; $p<.001$). Subjects' scores were significantly higher with easy than with difficult inference forms (see Table 2). Pairwise comparisons (with Bonferoni's correction) indicated that performance with true content was signficantly better than performance with both false content ($F(1, 43)=25.44$;

$p<.001$) and neutral content ($F(1, 43)=66.81$; $p<.001$). Performance with false content was also significantly better than performance with neutral content ($F(1, 43)=7.32$; $p<.01$) (see Table 2).

With the covariate omitted, a significant interaction was observed between difficulty of inference forms and content ($F(2, 86)=18.61$; $p<.001$). Subjects scored significantly higher on easy arguments than on hard ones when reading stories with true content ($F(1, 43)= 29.36$; $p<.001$), with false content ($F(1, 43)=174.73$; $p<.001$) and with neutral content ($F(1, 43)=287.84$; $p<.001$). However, the difference was greatest for the neutral story, somewhat less for the false story, and least for the true story (see Table 2).

Significant differences also were found when the effects of content on both difficult and easy inference forms were considered. With difficult forms, a significant effect for content was found ($F(2, 86)=42.66$; $p<.001$). Pairwise comparisons indicated that with difficult forms, performance with true content was significantly better than performance with either false ($F(1, 43)=30.57$; $p<.001$) or neutral content ($F(1, 43=74.10$; $p<.001$), and performance with false content was significantly better than performance with neutral content ($F(1, 43)=9.65$; $p<.01$). No effects for content were found with easy inference forms; college-aged subjects performed approximately equally well with easy arguments whether they were presented with true, false, or neutral content.

Discussion

In the earlier experiment with skilled readers (Franks, 1989), no differences in overall performance on this measure were observed between seventh grade and college. Including a broader range of reading skill with seventh graders resulted in a lower overall mean for this age group in the present experiment, and a significant difference between seventh grade and college students. However, since the mean for college students in the present experiment was higher than in the earlier study, this result cannot be said with certainty to reflect a genuine age trend.

The interaction of reading skill with the content variable among seventh graders raises interesting questions about reading and thinking and how the two may be related. For 12- and 13-year-olds, the ability to reason from false premises expressed in narrative form is correlated with reading skill. Perhaps this ability is

part of what makes a skilled reader, since the capacity to set aside one's own prior knowledge and focus only on what is stated in a passage is needed for many kinds of comprehension. It may also be true that the suspension of disbelief required by reading narratives promotes the development of the ability to reason from premises that are inconsistent with one's prior knowledge.

For college students, reading ability had a general effect on inferential comprehension, but did not interact with either content or difficulty (though Figures 1 and 4 indicate the same general pattern of effects for the different content types at both ages).

When only within-subjects effects are considered, however, an interesting difference is found between the two experiments with regard to content effects. In the first experiment, effects for content were significant for both easy and difficult arguments for all age levels. In the second experiment, this was also true for seventh graders, but for college students, content effects were found only for difficult arguments. These college students were able to set aside their prior knowledge and draw conclusions based only on the form of premises presented in the stories, as long as the inference forms presented were not too difficult. Younger subjects' performance appears to have been affected by their prior knowledge even with easy arguments. Though no significant interaction with age and content was found in the first experiment, the results of the second suggest that there may be some improvement with age in the ability to reason from premises inconsistent with one's prior knowledge, provided the type of inference required is not too difficult. This effect was also observed in another sample of adults on the same reasoning task (Franks, 1992).

From the perspective of reading comprehension, the relative difficulty of the specific argument types used in this study is not particularly important. What is important about the effects of difficulty observed here is the demonstration that inferring information not stated in a passage is not a simple, unitary operation that readers will always perform once they have learned to do so. Rather, readers' ability to make inferences about the information they read is affected by the form in which that information is expressed. Poor performance on some inferential

questions may be the result not of failure to infer unstated information, but of faulty deductions based on the form in which information is presented.

The content effects observed also relate to the concept of metalogic discussed by Moshman (1990). These results support the view that the relationship between task content and subjects' own knowledge of the world can affect subjects' performance with logical inference questions. This suggests that the metalogical ability to set aside one's own knowledge and focus on the form of the premises is an important part of drawing logically necessary conclusions. While the results of this study do not offer strong support for developmental trends in this ability, the interaction between content and difficulty found among college students, but not seventh graders, is suggestive of some age-related development. Other studies dealing with the ability to distinguish between the form of an argument and its content have found improvement with age (Hildyard, 1979; Hildyard & Olson, 1978; Moshman & Franks, 1986; Franks, 1993). However, few studies of this ability have been conducted, not all have involved the same age groups, and all have involved different tasks. Clearly further exploration is needed.

The marked effects of reading skill on overall performance for both seventh graders and college students offer an opportunity to consider the relationships between general levels of cognitive development and specific acquired skills. When readers of above-average skill were compared, as in the earlier study (Franks, 1989), no differences were observed between seventh grade and college, though fourth-grade performance was significantly lower. Since this lower performance was by skilled fourth-grade readers with easy arguments, it seems likely that it reflected a general level of cognitive development rather than specific skill deficits.

In the present study, however, the ability to reason from false premises was related to reading skill. This can be seen as an example of the way various factors other than level of cognitive development can affect performance on cognitive tasks. Moshman & Franks (1986) found that seventh-graders' ability to distinguish arguments on the basis of validity, regardless of their truth or falsity, was initially lower than that of adults, but improved to adult levels when they were given examples, instruction, and feedback. Adults did not need this kind of help; they spontaneously made the distinction. Perhaps seventh graders, whose

understanding of logical necessity is not fully developed, are aided on tasks requiring this understanding by their level of reading skill.

By the time subjects reach college age, reading skill is less strongly related to their ability to reason from false premises, though it does have a general effect on performance. By this age, young adults appear to have a fully developed understanding of logical necessity (Moshman & Franks, 1986), so it is not surprising that in the second experiment they were able to set aside their prior knowledge and reason only from premises given, as long as the inference forms were not too difficult. By young adulthood, even poorer readers may understand this concept fully, so reading skill deficits may not affect their ability to reason from false premises so strongly.

The effects of the Difficulty factor offer further illustration of the interaction between reading and thinking. Difficult inference forms were much more difficult than easy ones for all readers, regardless of their skill; performance with these forms does not improve significantly as reading skill improves for either seventh graders or college students, as illustrated in Figures 2 and 4. Reading skill alone cannot account for performance on inference tasks; even skilled readers have difficulty with some inference forms.

The results of this study illustrate an interesting aspect of the relationship between reading and thinking. A high level of reading ability helps students to reason about what they read, but does not by itself account for all forms of inferential comprehension. Concepts from both the logical reasoning and the reading comprehension areas, when explored together, contribute usefully to our understanding of reading comprehension.

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Table 1

Means and Standard Deviations for Three Content Types with Easy and Difficult Inference Forms (Seventh Grade Sample)

	Easy Forms	Difficult Forms	All Forms
True Content	2.66	1.70	4.36[a]
	(.47)	(.85)	(.95)
False Content	2.35	1.26	3.63[a]
	(.80)	(.60)	(1.06)
Neutral Content	2.28	.93	3.20[a]
	(.68)	(.47)	(.88)
All Contents	7.30[b]	3.90[b]	11.20[c]
	(1.34)	(1.37)	(1.98)

[a]Mean score for each content type (out of 6 possible)

[b]Mean score for each level of difficulty (out of 9 possible)

[c]Mean total score for all stories (out of 18 possible)

Table 2

Means and Standard Deviations for Three Content Types with Easy and Difficult Inference Forms (College Sample)

	Easy Forms	Difficult Forms	All Forms
True Content	2.84	2.10	4.93[a]
	(.37)	(.80)	(.85)
False Content	2.75	1.30	4.05[a]
	(.49)	(.55)	(.75)
Neutral Content	2.64	1.05	3.68[a]
	(.53)	(.30)	(.60)
All Contents	8.23[b]	4.43[b]	12.66[c]
	(.89)	(1.13)	1.72

[a]Mean score on each content type (out of 6 possible)

[b]Mean score on each level of difficulty (out of 9 possible)

[c]Mean total score on all stories (18 possible)

Figure 1

Effects of reading ability on 7th graders' performance with true, false, and neutral content.

Figure 2

Effects of reading ability on 7th graders' performance with easy and difficult inference forms.

Figure 3

Effects of reading ability on college students' performance with easy and difficult inference forms.

Figure 4

Effects of reading ability on college students' performance with true, false, and neutral content.

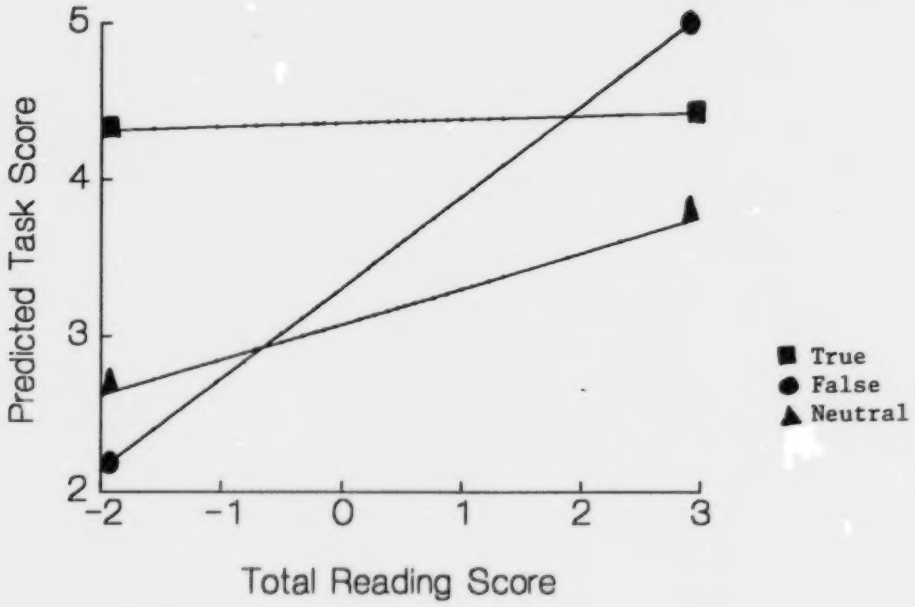
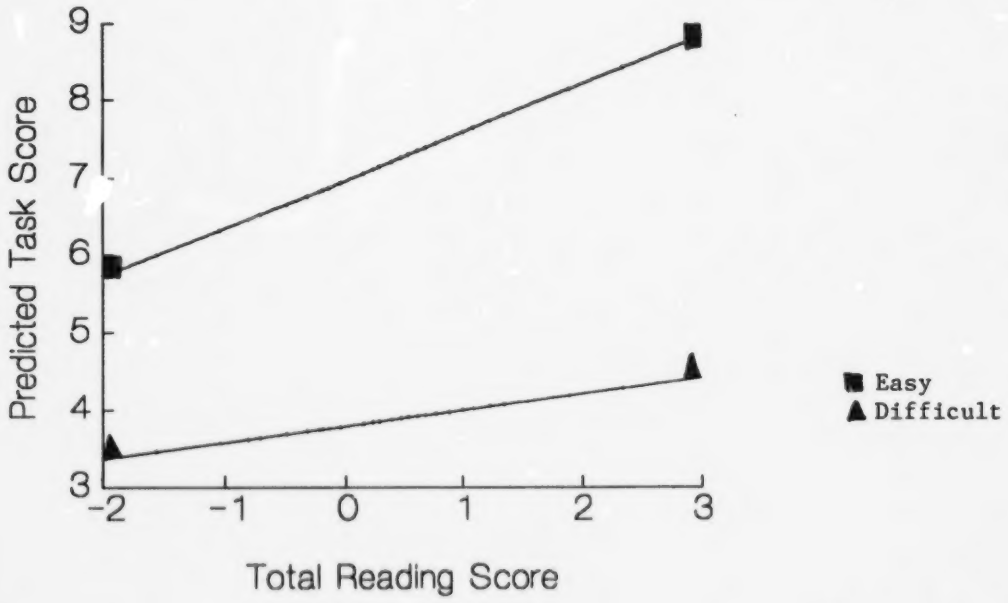

Predicted Task Score
5
4
3
2
-2
-1
0
1
2
3
Total Reading Score
True
False
Neutral

Figure 1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5
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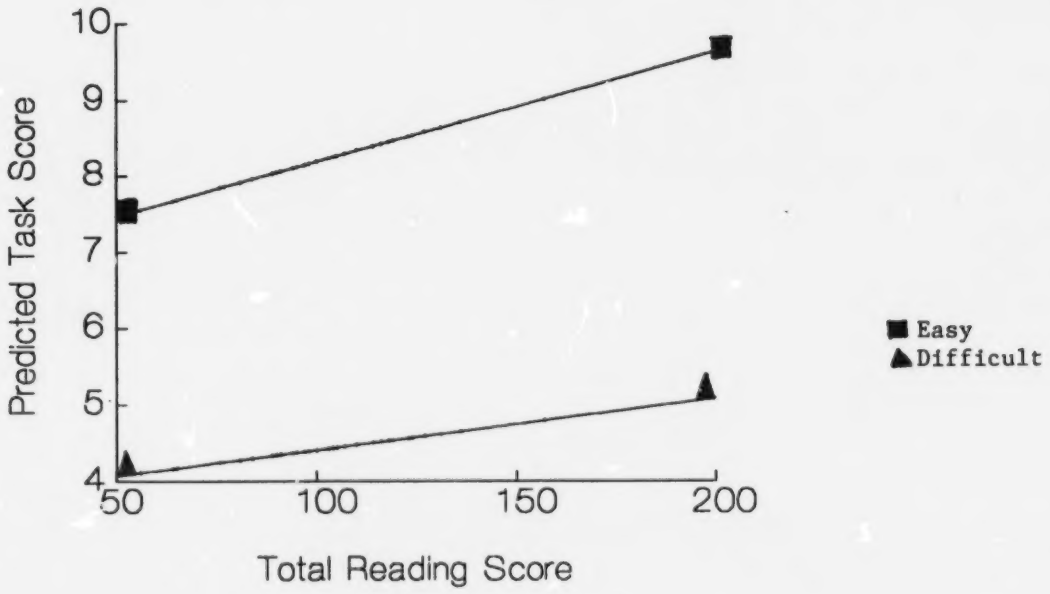
-1
0
1
2
3
Total Reading Score
Easy
Difficult

Figure 2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8
7
6
5
4
50
100
150
200
Total Reading Score
Easy
Difficult

Figure 3

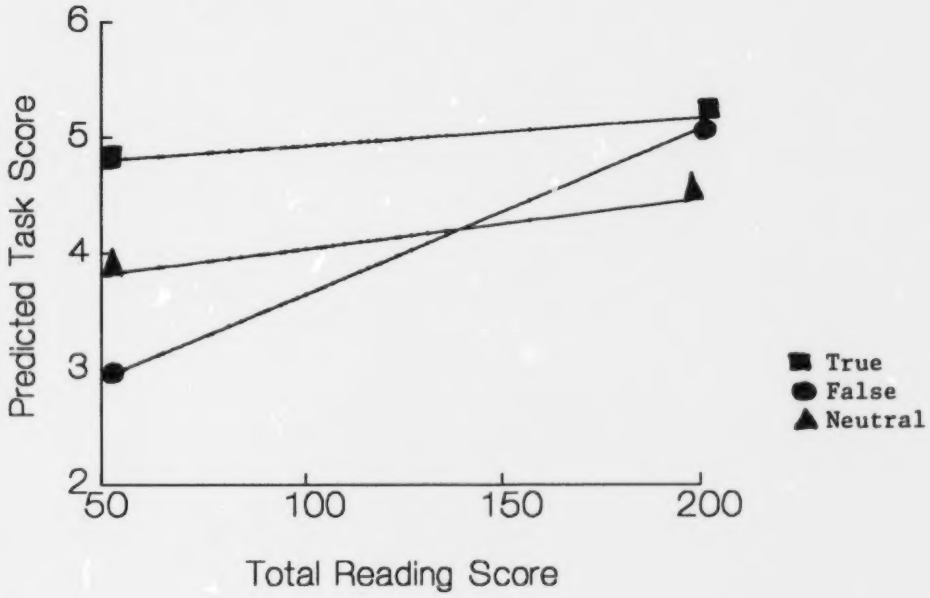
6
5
4
3
2
Predicted Task Score
50
100
150
200
Total Reading Score
True
False
Neutral

Figure 4